Applications of Sea Ice Motion and Deformation Derived from Satellite Data

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ABSTRACT

QuikSCAT backscatter, AMSR-E and DMSP SSM/I radiance data have been used to derive sea ice motion for both the Arctic and Antarctic region using the wavelet analysis tracking method. All results from QuikSCAT, AMSR-E and SSM/I in the Arctic for fall/winter period are compatible with buoys and can then be merged by some data fusion methods to generate composite sea ice motion maps for more complete coverage. Furthermore, based on this merged data set, daily sea ice deformation (divergence and maximum shear) maps have been produced and show consistent spatial and temporal patterns. For summer ice, in order to focus the tracking templates in time, descending data are separated from ascending data during pre-processing. Due to the high resolution of AMSR-E 89 GHz data, sea ice motion maps from AMSR-E 89 GHz descending and ascending data are complementary each other, and sea ice drift in summer has been derived by merging results from descending with ascending data for composite daily sea ice motion maps. The general circulation pattern of the derived summer sea ice drift agrees with buoy data. In this study, principal component analysis of both the merged ice tracking result from satellite data and pressure field from buoy have also been examined for the relationship between the principal components and eigenvectors from these two data sets. While the result shows that principal components of modes 1 and 2 from two data sets are highly correlated, which confirms that wind forcing is a major factor driving the ice drift, it also reveals that other high energy modes are not highly correlated, which may be caused by coastal effects. Principal component analysis of Arctic sea ice motion during fall/winter period in different years shows that the reverse of dominant modes or patterns is related to the Arctic Oscillation.

Keywords: Sea ice motion, sea ice deformation, satellite data, remote sensing, wavelet analysis, principal component analysis, and Arctic Oscillation.

1. INTRODUCTION

Sea ice covers seven percents of the surface of our planet. It is one of the most important and variable components of the planetary surface and is the key to understanding many of the basic questions about the energy balance of the earth. Sea ice is not a passive stationary sheet of material covering the sea surface, but is driven by winds and currents resulting in ridges, leads, and coastal polynyas as the response of the ice to these stresses[1]. The estimates of sea ice motion is important to the study of sea ice dynamics and provides a natural resource for deriving ice deformation, which is responsible for the opening and closing of leads and associated ridge formation and therefore influences the sea ice mass balance. Early estimates of ice drift were obtained from ship records, manned ice stations, and reconnaissance aircraft. With the advent of satellite systems, satellite observations have been used to derive sea ice motion and other parameters and help achieve a much better understanding of polar ice drift since satellite data provide better spatial and temporal coverage than any other means. *Liu et al.*[2] gave a short survey on the applications of satellite observations in deriving polar sea ice drift. They also demonstrated that sea ice motion derived from wavelet analysis of Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) data and NASA scatterometer (NSCAT) data gave good quantitative agreement with the ice motion derived from buoy data in the Arctic for November and December 1996, and ice motion from these two satellite data sets were compatible and complementary to each other. Therefore, three sea ice motion daily results from SSM/I, NSCAT, and buoy data could be merged by some data fusion techniques to generate composite maps with more complete coverage of sea ice than those from a single data source. *Zhao et al.*[3] reported similar finding for sea ice motion derived from wavelet analysis of NASA Quick Scatterometer (QuikSCAT) data and SSM/I data in the Arctic for the period from October 1999 to March 2000 as well as the capability of QuikSCAT data to provide sea ice motion for early and late summer. However, the accuracy of sea ice motion derived from satellite observations is limited by satellite spatial and temporal resolutions and the fact that satellite observations need to balance between spatial and temporal resolutions, with higher spatial resolution inevitably reducing temporal resolution and vice versa.